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THE EFFECTS OF MAGNETIC STORM PHASES ON F-LAYER IRREGULARITIES FROM AURORAL TO EQUATORIAL LATITUDES

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PROGRESS DURING THIS PERIOD

In progress is a major study of the effect of the ring current on the sub-auroral and equatorial generation of patches of irregularities. In addition studies are on-going for determining the dynamics of electric field penetration in latitude with the start of a major geomagnetic storm.

For the first time (except for showing a small data set for the 1987 IES) simultaneous observations of irregularities at high and equatorial latitudes will be utilized. The studies use scintillation and spread F data as well as optical observations for data from 1971-1989. Two basic concepts are being studied. For the high latitude region the generating source during magnetic storms descends to lower latitudes with velocities ranging from 80-300 meters per second. The effect of the source weakens as it moves equatorwards.

One example is the following study of the storm period of March 13-15, 1989. The great magnetic storms of March 13-15, 1989 indicated the depth of penetration and weakening of the electric field in an equatorward motion. At Millstone Hill, MA, all sky observations of 6300 A aurora and SAR arcs are made routinely by the Boston University Mobile Ionospheric Observatory. For the night of March 14, when observations were allowable through clouds, high saturated aurora were observed from 30* to 55* Geographic North. The meridional component of the all sky optical data for March 15 show continuous high levels from 01 to 0510 UT with a high level isolated patch noted from 0535 to 0550. On the Hanscom Field scintillation data, high levels can also be noted in these time periods. The Ramey AFB data for March 15 do not show any scintillation activity. The electric field on this day did not penetrate to this latitude. For this night, irregularities and aurora reached (and passed) 53* CGL but failed to reach the 30.5* CGL intersection of Ramey AFB. The timing of the descent, i.e. essentially 2 hours 35 minutes to move 22* of latitude on March 14th and the weakening as shown on March 15 are indicative of the way the dynamic development takes place during the initial phases of the magnetic storm.

For the equatorial region the concept that is being developed is as follows: if the maximum level of the ring current energy, as shown by the value of Dst, is reached in the early afternoon, then the F-layer height will be affected. The reduction of the normal height during months when irregularity activity is noted almost every night, essentially inhibits the generation of irregularities activity during that night. If the maximum Dst level occurs in the midnight to post-midnight time period then the layer height will be increased, falling after the ring current recovery period and irregularities will be produced. It should be noted that these concepts follow from early work in spread F and scintillation data. The difference is the use of the Dst maximum as the keynote in the effect and in careful use of the local time.

By understanding the time development of irregularities, forecasting those periods when intense amplitude and phase fluctuations will be observed can be possible. At present there are thousands of users of the transmissions for the satellites in the 250 MHz range. The effect of amplitude fluctuations can be minimized with diversity methods used during magnetic storms; it is up to the user community to demand attention to this problem.

Dr. J. Aarons has prepared a paper for presentation and publication at an AGARD EPP symposium. We have extracted the abstract and a portion of the introduction in order to see the directions the studies are taking.

THE DYNAMICS OF F-LAYER IRREGULARITIES RELATIVE TO SPACE TIME AND FREQUENCY DIVERSITY

Jules Aarons

ABSTRACT

With the statistics of morphology of F-layer irregularities now in hand, it is possible to forecast in broad terms what to expect at equatorial, auroral and polar latitudes during various levels of solar flux. With the beginning of an understanding of the effect of the various phases of magnetic storms on generating irregularities as noted from the solar wind, ring current, convection, auroral index, and magnetic index parameters, it is possible to roughly forecast levels of F-layer irregularity intensity. With these in hand, the utility of space, time, and frequency diversity can be evaluated. Diversity could be used if forecasting in real time was possible. This study outlines the dynamics of irregularity generation and inhibition during various phases of ring current and magnetic activity, leaving the detailed use of diversity methods to the system operators. For the system operators, the duration and severity of the effects must be evaluated for the particular location.

INTRODUCTION

Irregularities at F-layer heights produce phase and amplitude fluctuations on signals traversing the ionosphere. They therefore have an effect on radio systems designed, developed or envisaged which utilize frequencies from 20 MHz to 6 GHz. If the system is in the field, the using organization is usually left to determine the need and utility of correction methods. The using organization has to develop the day to day perturbations on the system. In the case of dealing with the problems that irregularities produce (fading, loss of signal, false targets) the designer of the equipment has to be able to supply methods of minimizing these effects. This has to mean a decrease in capability. It is there that the evalution of frequency, time or space diversity has to be made.

For forecasting ionospheric propagation parameters we have two distinct needs i.e. long term statistical effects and dynamic effects. The planner is only concerned with the effects of magnetic storms such as were observed March 13 -15, 1989 as a piece of his statistics, perhaps the 99 percentile bracket. Data and analyses are at hand to forecast the morphology of F-layer irregularities. Forecasting the morphology allows the evaluation of the utility of operating systems and the planning of back-ups.

However, the users of satellite communications at 250 MHz were dismayed on March 13 and 14, 1989 when auroral effects on transmission were noted as far from the auroral zone as Mexico and Puerto Rico. Forecasting the dynamics will allow the use of real time warning and possible use of diversity or other means of characteristics of the irregularities as a function of geophysical conditions. It allows the system to warn operators about impending problems. In this paper, we shall on two geophysical areas where it is possible to develop forecasting methods to determine the dynamics of irregularity generation; we shall look at the auroral and equatorial regions.

PUBLICATIONS AND PRESENTATIONS

The AGARD paper noted above has been sent to ONR for clearance.

Goodman, J. and J. Aarons (1990) Ionospheric effects on modern electronic systems Proc. IEEE March 1990